

## CHAPTER 13

# OPERATING PRINCIPLES OF A REPRESENTATIVE AIR SEARCH RADAR, AN/SPS-29 (Part II)

## INTRODUCTION

The complete coverage of Radar Set AN/SPS-29 is contained in two parts—chapter 12 and chapter 13 of this training course. Chapter 12 (part I) includes a functional description of the radar system and operating principles of the modulating and transmitting functional sections. This chapter (part II) treats the receiving and ranging functional sections and all associated controls and monitoring circuits.

## RECEIVING FUNCTIONAL SECTION

The receiving functional section develops video signals from the echo r-f pulses and displays this video on the range and PPI indicators. A double-conversion type receiving system is used. The receiving functional section is contained in four major units: the radar receiver (fig. 12-1, A), the control monitor group, the transmitter group, and the radar set control.

The input r-f signals (echos) from the duplexer in the frequency range of 215.5 to 224.5 mc are amplified and converted to a 30-mc intermediate frequency in the receiver. The i-f signal is further amplified in the receiver by a group of i-f preamplifier stages.

The receiver amplified i-f signal is fed to the control monitor group where a second conversion process produces an intermediate frequency of 3.75 mc. After further amplification and detection in the control monitor group, the detected video signal is fed to the range indicator and along four separate video output channels to PPI type indicators (if used).

The master oscillator in the transmitter group supplies the basic heterodyning signal which is multiplied and used in the receiver mixer to produce the 30-mc first frequency conversion i-f signal. The master oscillator is also used in generating the r-f signal during

transmission as discussed in chapter 12 of this text.

The receiving section uses the radar set control to provide control and monitoring circuits for the receiving stages. The noise figure check, receiver gain, shm, and stc controls, and the receiver noise indicator, are mounted on the radar set control.

## RADAR RECEIVER

As foretold, the circuits included in the radar receiver chassis (fig. 13-1) provide selection, heterodyning, and i-f amplification of the received echo signal.

## R-f Amplifiers

The receiver block diagram is shown in figure 13-2. The r-f signal from the duplexer in the output radio frequency amplifier (fig. 12-1, A) is coupled through K3002 (in the position shown) to cascode r-f amplifiers V2401 and V2402.

A cascode arrangement of triode r-f amplifiers (fig. 13-3) is used because of its low noise characteristics (as compared to a pentode tube), while the amplification is approximately the same as that which could be obtained in a pentode. Also, because V2402 is connected as a grounded grid amplifier, having the input signal between cathode and grid, the effects of shunt capacitance usually encountered from grid to ground is eliminated.

The signal input to V2401 is developed across L2401B. The output is coupled by C2404 to the cathode of V2402. The output amplified signal from the V2404 plate is applied to the V2404 r-f mixer grid.

Neutralization is accomplished in V2401 by a signal coupled from the plate to the grid of V2401 through C2403 and L2402. This action prevents undesired oscillations in V2401.

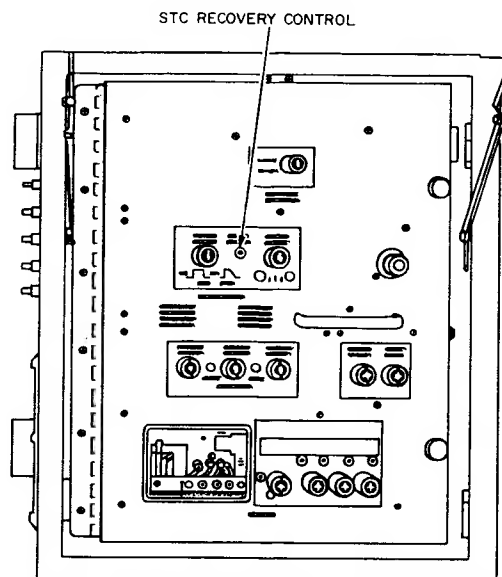
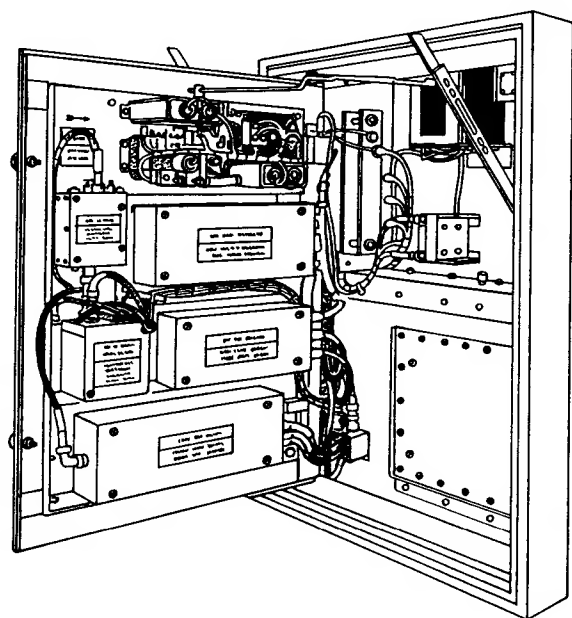


Figure 13-1.—Radar receiver. 032.229

#### Bias Pulser

During transmission, a negative blocking pulse is applied to the V2401 grid via J2403 to prevent possible damage to the tube. The circuit which produces this pulse consists of a multivibrator, V2901 and a cathode follower, V2902.

As stated in chapter 12, the transmitter r-f output pulse occurs 3  $\mu$ s after zero time delay. To ensure blocking of the receiver r-f amplifier, V2401, before the transmitter pulse occurs, the bias multivibrator, V2901, is triggered into action at 1  $\mu$ s after zero time delay. The 1  $\mu$ s trigger pulse is obtained from delay line DL1801 (fig. 12-3).

Stage V2901 is a conventional one-shot multivibrator with its B section normally conducting. The application of the positive-going 1  $\mu$ s delay trigger pulse causes the A section of V2901 to conduct for approximately 20  $\mu$ s. During this period, the negative-going plate output of V2901A is coupled through C2902 to the V2902 grid. The resulting negative-going output at the V2902 cathode is fed through C2903 and L2401B to the r-f amplifier V2401 grid. The pulse is sufficiently negative to hold V2401 beyond cutoff during the period of the transmitter output pulse.

#### Mixer-Local Oscillator

During the receiving interval, the V2402 output is applied to the control grid of r-f mixer V2403. The mixer also receives, at the same grid, a local oscillator signal from buffer V2404 (fig. 13-2).

The local oscillator (heterodyne) signal originates in master oscillator stage (fig. 12-9). The oscillator frequency is crystal controlled in ten steps from 61.833 to 64.833 mc. The oscillator signal is applied from V402 (fig. 12-8) to local oscillator amplifier V409 (fig. 13-2). After further amplification in V2406 and tripling to a frequency between 185.5 and 194.5 mc in V2405, the local oscillator signal is fed through buffer V2404 to the mixer, V2403, grid (fig. 13-3).

The mixing action in V2403 produces the original, sum, and difference frequencies across plate load inductor L2418. However, the pi filter which comprises C2416, C2414, and L2412 limits the output to a narrow band of frequencies centered around the 30-mc difference frequency. The i-f signal is fed to i-f preamplifier V2501 (fig. 13-2).

#### Meter Circuit

Meter M2206 is used to set the plate currents of V2401 and V2402. In operation, it is

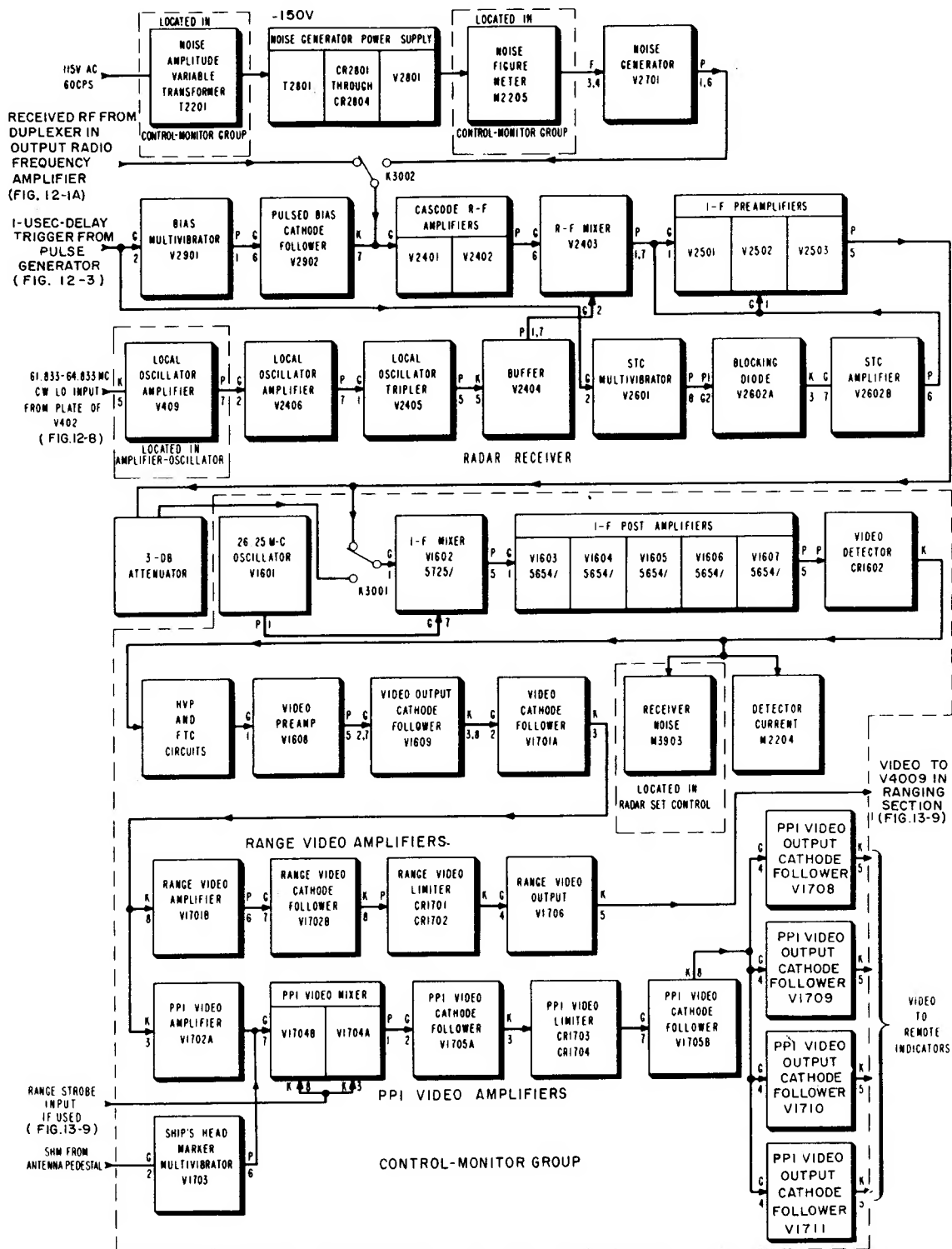
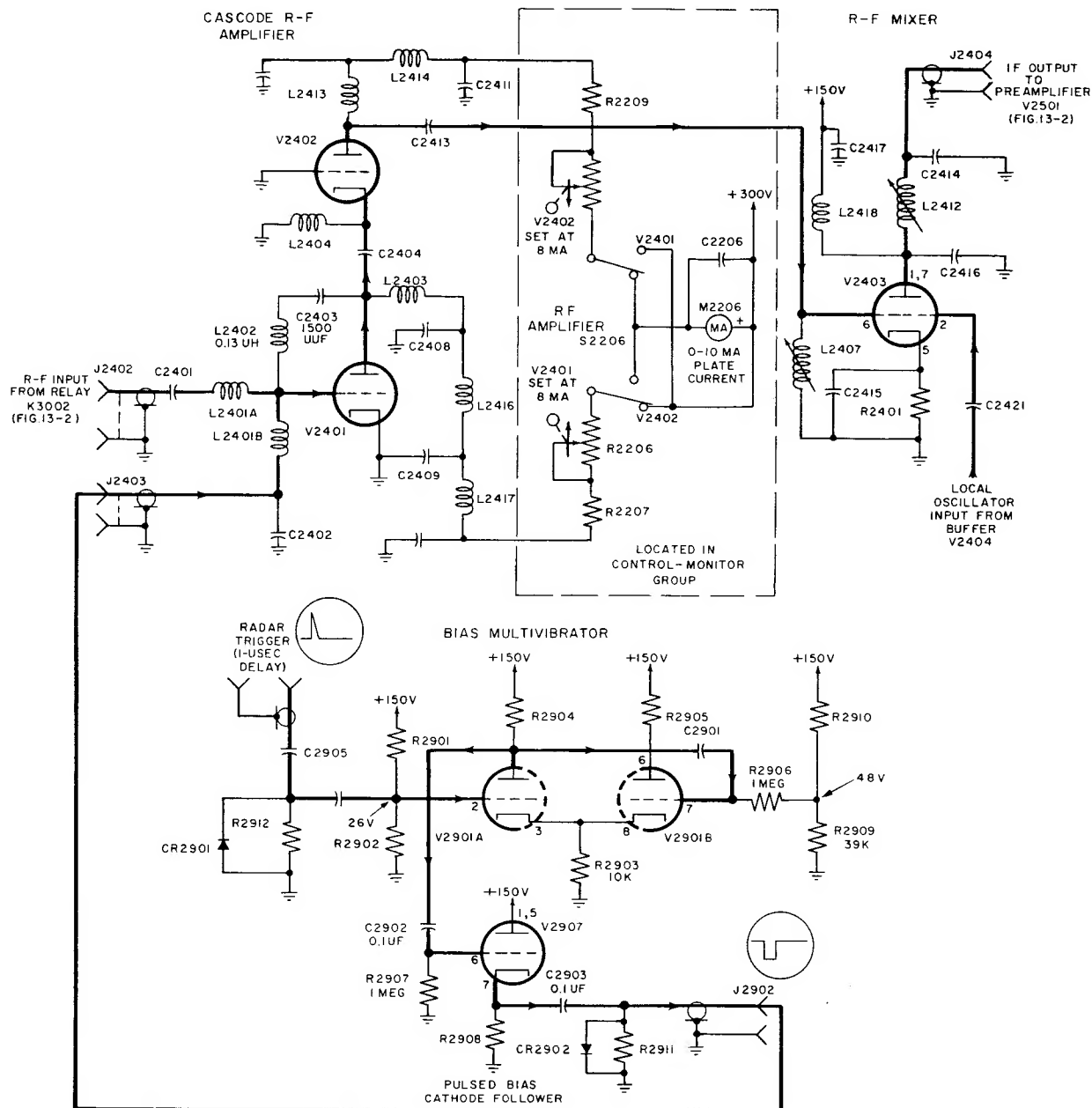


Figure 13-2.—Radar receiver block diagrams. 032.230

## CIRCUITRY OF SHIPBOARD ELECTRONICS EQUIPMENT

Figure 13-3.—R-f and mixer circuits. <sup>032.231</sup>

desirable to make the conductance of V2401 the same as that of V2402 so that the full available power gain of the grounded cathode triode can be utilized in the grounded grid triode. In order to accomplish this balanced condition, a variable resistor is included in the plate circuit of each tube.

The plate potential for V2401 is obtained through L2403, L2416, L2417, R2207, R2206, and the closed contacts of S2206. The plate

potential of V2404 is obtained along a similar path through R2208 when S2206 is in the position opposite to that shown.

Switch S2206 permits the plate current of either V2401 or V2402 to be monitored by the meter.

With S2206 first in the position shown and then in the other position, the plate current of V2401 and V2402 should be set at 8 milliamperes. This establishes equal conductivity in

both tubes and the full amplification of V2401 can be passed through V2402 without introducing distortion (noise).

### I-f Amplifiers

Three conventional i-f stages, V2501, V2502, and V2503 (fig. 13-2), amplify the 30-mc i-f signal from V2403. The gain of V2501 and V2502 is determined by the setting of a remote receiver gain control on the radar set control (fig. 13-4) or by a local gain control on the control monitor group. These controls vary the bias on V2501 and V2502.

The gain of V2501 and V2502 is also controlled by a negative-going sensitivity time control (STC) voltage which is applied to the control grids of these stages. Several undesirable conditions are present during normal operation of the radar receiver. When the receiver gain is at maximum for observation of distant targets, nearby targets and the sea produce very strong return signals which saturate the receiver. Another source of echo saturation comes from nearby targets in line with the antenna side lobes, which produce indications that are accurate in range but erroneous in bearing.

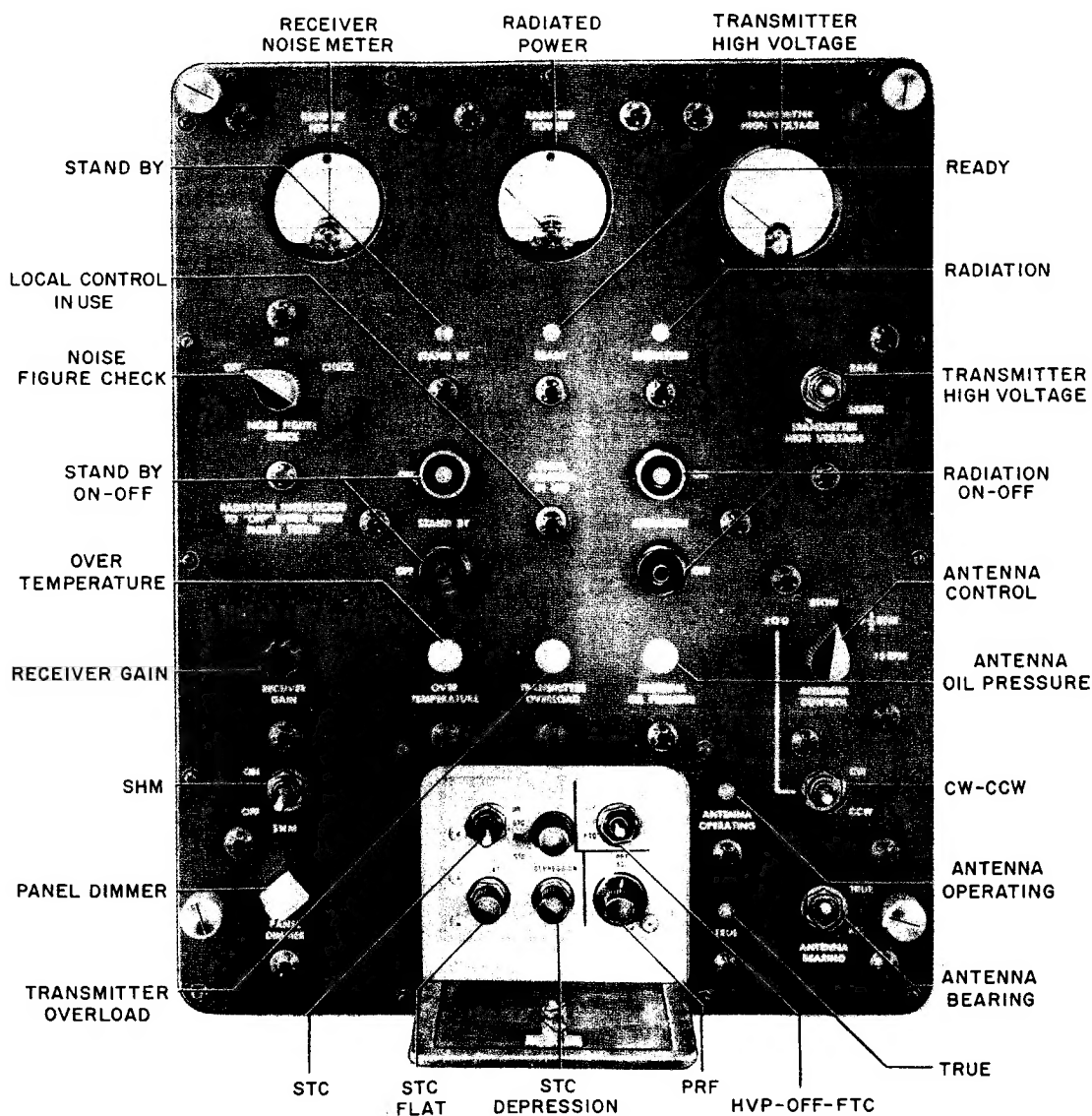


Figure 13-4.—Radar set control.

The stc circuit, which comprises V2601, V2602A, and V2602B, is used to produce a negative transient voltage which is applied to the control grids of the first two i-f preamplifiers (V2501 and V2502) after each transmitted pulse. This voltage reduces the i-f gain after each transmitted pulse, and allows the stages to recover exponentially until normal gain is restored. Thus, strong signals from nearby targets and false signals from side lobe targets are suppressed, allowing optimum definition on the indicator at all times.

The circuit operation of a representative stc circuit is explained in the treatment of the AN/SPS-10D radar set in chapters 10 and 11 of this text. A further consideration at this point is not necessary.

During normal operation of the receiver, the output from the final i-f preamplifier (V2503) is fed through relay K3001 (contacts in the position shown), to i-f mixer V1602. When it is desired to measure the noise level in the receiver, a 3 db pad is inserted in series with the V1602 input line by K3001 (contacts opposite to the position shown), which causes the receiver output to be exactly half of its normal value.

The method of noise measurement is treated later in this chapter. It is sufficient at this time to note the insertion of the attenuator in the signal path when noise measurements are being made.

## CONTROL MONITOR GROUP

In mixer V1602, which is located in the control monitor group, the 30-mc i-f signal from V2503, (or the 3 db attenuator) is heterodyned to produce a lower intermediate frequency, so that a narrower i-f bandpass can be obtained for a given "Q" in the i-f tuned circuits. Because the transmitted pulse, and likewise the return echo, is low in high frequency content due to the use of a  $\sin^2 \theta$  shaped transmitter pulse, wide bandpass i-f stages are not needed. This feature could not be used in the AN/SPS-10D or any radar system which transmits the more conventional square wave pulse without considerable loss of the high frequency components contained in the pulse.

In order to obtain the narrower bandpass, the i-f signal is converted from 30 mc to 3.75 mc in V1602. The heterodyne signal for V1602 is applied from 26.25-mc oscillator V1601. The 3.75-mc difference frequency output from V1602 is amplified in five stages of i-f post amplification comprising tubes V1603 through V1607.

## Video Detector Circuits

The 3.75-mc i-f signal from V1607 (fig. 13-2) is applied to a video detector diode, CR1602 (fig. 13-5). The detector delivers

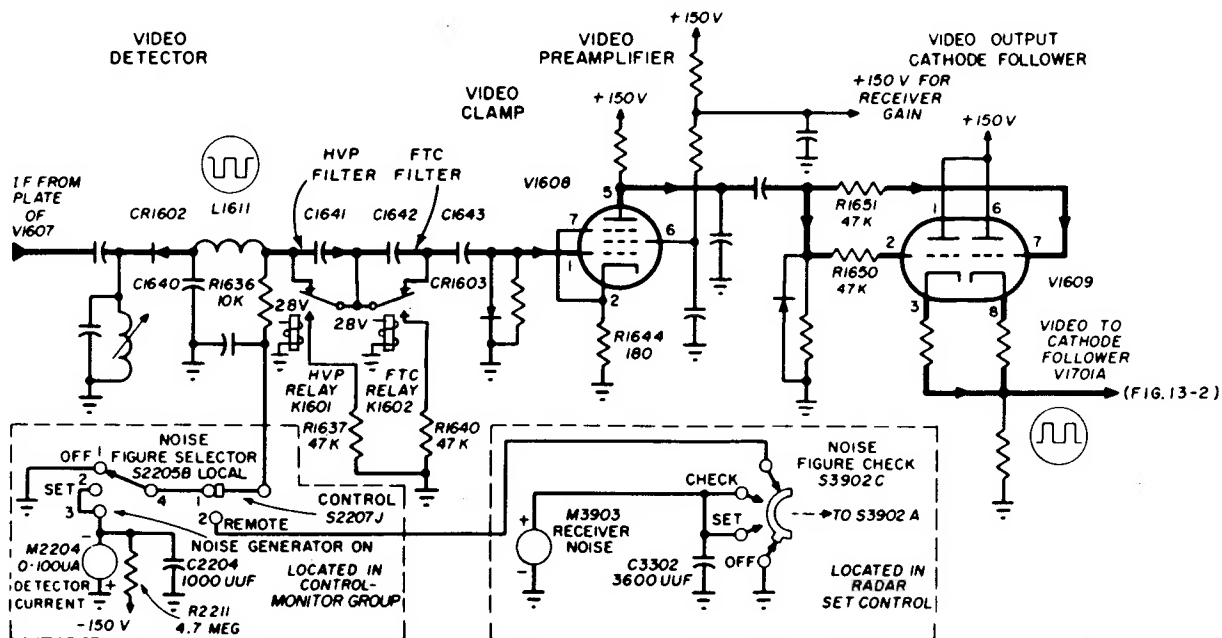


Figure 13-5.—Video detector and video preamplifiers.

032.233

negative-going video signals through the filter network consisting of L1611 and C1640. Under normal conditions this output is fed through the closed contacts of K1601, K1602, and C1643 to the grid of V1608. The ftc (fast time constant) or hvp (high video pass) filters will prove helpful in identifying targets during interference conditions caused by return signals from closely spaced targets such as hills or islands, or by modulated cw jamming.

Relay K1601 is energized from the -28-volt supply (discussed later) when the HVP-OFF-FTC switch on the radar set control panel is in the HVP position. In this condition the K1601 contacts are down (opposite to the position shown). Relay K1602 is energized from the same supply when the switch is in the FTC position.

The hvp and ftc filters are short time constant differentiating networks which consist of C1641-R1637 and C1642-R1640, respectively. These filters offer low impedance to the high frequency components in the video pulse. By this action, long duration echo pulses are differentiated into narrow spikes which correspond to the leading edge of the original input pulse. Thus, a pattern of closely spaced targets which would normally blend into one large solid block on the indicator is resolved into individual patterns corresponding to each target. The filters produce sharp pulses for each input pulse regardless of the input pulse duration. These filters also eliminate modulated c-w interference, which normally tends to overload the video circuits and obscure the desired targets.

Diode CR1603 clamps the grid to ground potential of V1608 at zero volts. This prevents positive-going transient voltages at the filter networks from saturating V1608 at the trailing edge of the video pulse.

#### Video Preamplifier

A stage of video preamplification V1608, (fig. 13-2) and two cathode followers, V1609 and V1701A, are employed in the video circuits after detection to boost the signal level and to isolate the detection circuits from the rest of the video stages. Stage V1701A supplies video signals to the cathodes of video amplifiers V1701B and V1702A. The low cathode to ground resistance of V1701A (not shown) lowers the V1701A output impedance so that the capacitance from the V1701B and V1702A cathode follower input to ground produces a negligible signal loss.

#### Range Video Amplifier

The major objective of the range video amplifiers (fig. 13-2) is to provide a constant signal amplitude to the range indicator. The video signal is amplified in V1701B, fed through cathode follower, V1702B and clipped to a predetermined level by CR1701 and CR1702. The clipping level which is set by a clipping adj control (not shown) determines the maximum signal amplitude to the range indicator.

#### PPI Video Amplifiers

Included in the PPI video amplifier stages (fig. 13-2) is a ship's head marker multivibrator V1703 and a video mixer V1704A and B in which all the video data required by the PPI is combined. The composite output is fed through a cathode follower V1705A, a limiter CR1703 and CR1704, and additional cathode followers to the remote PPI-type indicators.

For relative bearing, it is desirable to have an indication of the position of the target with respect to the ship's heading. This is accomplished by brightening the PPI sweep line when the antenna points directly over the bow of the ship.

The ship's heading marker (shm) multivibrator V1703A and B (fig. 13-6) is triggered when the ground connection is removed from the A section grid by the parallel operation of switches S4704 and S4705. The V1703 circuit is a keyed free-running multivibrator with its B section normally conducting. Removing the ground allows V1703A to conduct.

Microswitches S4704 and S4705 are located in the antenna pedestal, and are actuated by a cam (not shown). The cam is positioned so that its leading edge actuates S4704 at the instant the antenna is pointing directly over the ship's bow. An instant later, the cam causes S4705 to be actuated, and the ground is reapplied to the R1724-R1725 junction. This action stops the conduction of V1703A and the circuit returns to its normal condition. The microswitches are connected in parallel to shorten the duration of the V1703A conducting time.

The output of the shm multivibrator at the V1703B plate is a series of symmetrical distorted square waves which are coupled to the grid of PPI video cathode follower V1704B. The cathode follower is a part of the PPI video mixer stage. After mixing and limiting, the shm signal appears on the PPI scope as a solid line which flashes each time the antenna points over the ship's bow.



Figure 13-6.—PPI video mixing circuits.

The remaining stages of the PPI video amplifiers include a limiter CR1703 and CR1704, a cathode follower, V1705B, and four PPI video output cathode followers, V1708 through V1711. These stages are conventional in design and purpose. The four output cathode followers deliver the shm, PPI received video, and range strobe signals to the remote PPI indicators, and provide proper impedance matching.

A check of the receiver noise figure is a good method of determining the overall performance of the radar receiver. Noise

The noise generating diode, V2701, (fig. 13-7) produces noise over a wide frequency spectrum. The noise is the result of random emission of the electrons from the V2701



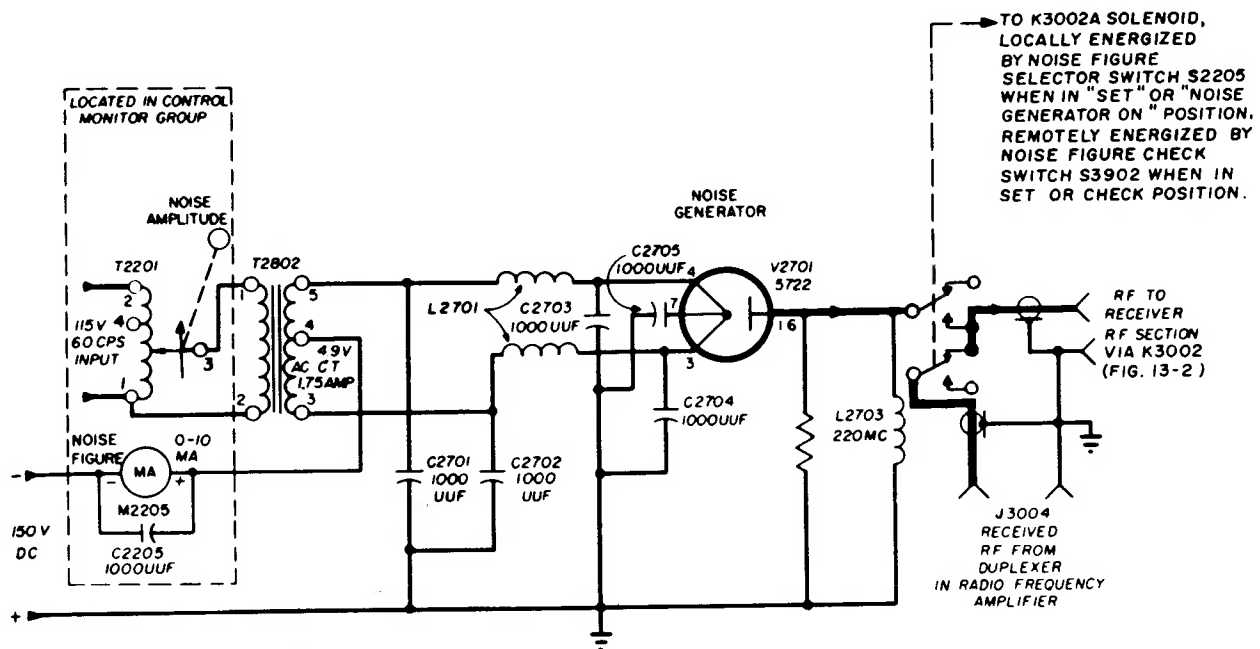


Figure 13-7.—Noise figure circuits.

cathode. The random emission appears as noise in the plate circuit of V2701.

Plate inductor L2703 is self-resonant at 220 mc and offers a low impedance to ground for noise occurring at all other frequencies. Thus, the noise coupled through K3002 when energized (opposite to the position shown) is limited to a band of noise frequencies centered around 220 mc. This signal is fed to the r-f stages in the receiver via K3002 when noise checks are being made.

Relay, K3002, is energized locally when the noise figure selector switch on the control monitor group is in the SET or NOISE GENERATOR ON position. The relay is energized remotely by the noise figure check switch on the radar set control when in the SET or CHECK position.

Noise amplitude variable transformer T2201 controls the voltage applied to the filament of V2701 through T2802. As the voltage is increased, the amplitude of the noise generated by V2701 is increased.

The d-c potential required by V2701 is applied to the filament through noise figure meter M2205. The meter is calibrated in decibels and measures the plate current of V2701 which is proportional to the generated noise.

## RANGING FUNCTIONAL SECTION

The ranging functional section translates the time interval between the transmitted and reflected signals to target range through means of a type-A oscilloscope presentation. The circuits of the ranging functional section are contained in the range indicator (fig. 13-8).

## RANGE INDICATOR

Target signals can be displayed at ranges of 5, 25, 100, or 250 miles. An expanded sweep feature enables closely grouped echoes to be separated in the presentation at any range for better differentiation. The circuits of the range indicator perform the basic operations of time-base generation, video amplification and display, and range determination. Time-base circuits establish sweep length and produce a sawtooth voltage for application to the horizontal deflection plates of the cathode-ray tube. Radar video signals are applied to the vertical deflection plates of the cathode-ray tube through a video amplifier channel. Amplification of the video signals is required in order to raise their magnitudes sufficiently to introduce an upward vertical deflection in the sweep trace indicative of target position.

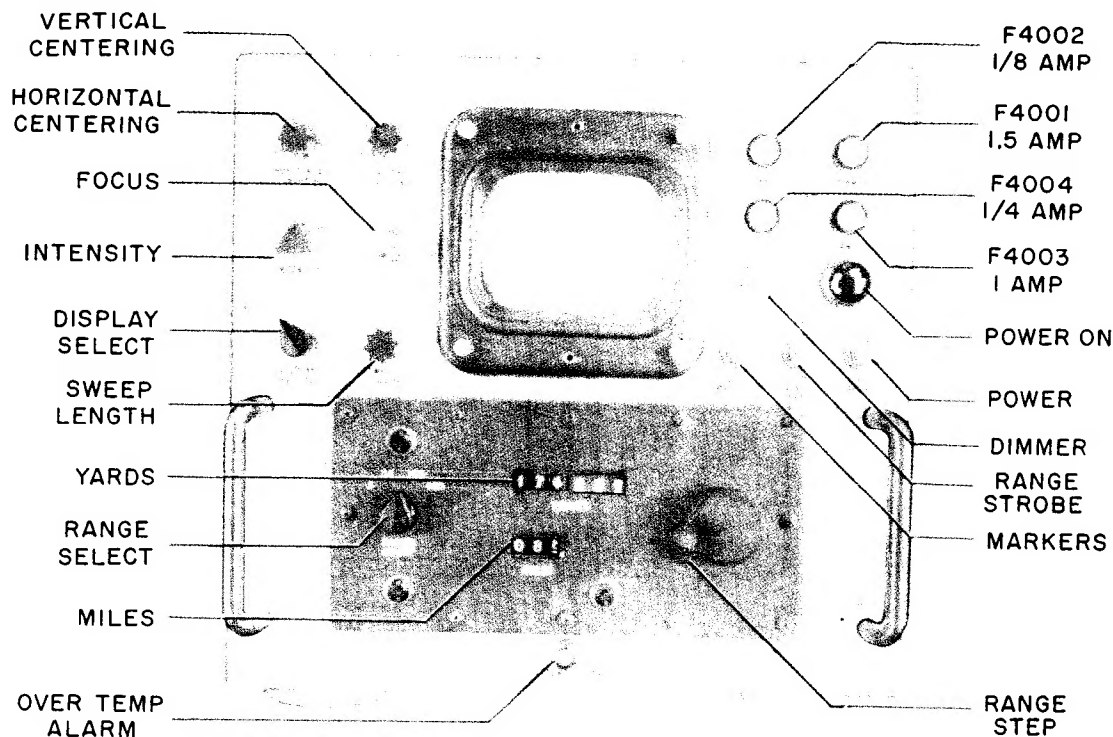


Figure 13-8.—Range indicator. <sup>032.236</sup>

The range determination stages facilitate accurate range measurements through the introduction of a variable-width step pulse in the presentation. Measurements are made by adjusting the trailing edge of the step pulse for coincidence with the target signal and reading out the distance on counters. The ranging section block diagram is shown in figure 13-9.

#### Time-Base Circuits

The time-base circuits are composed of trigger amplifier V4001A, range gate generator V4001B, and V4002A and B, sweep generator V4004A, sweep amplifier inverter V4003A and B, expand sweep generator V4005A and B, and expand sweep diode V4004B.

The trigger pulse for the sweep (gate) stages is received from the pulse generator (fig. 12-4). The input trigger pulse (fig. 13-9) is shaped and inverted in trigger amplifier V4001A. The range gate generator stages, when triggered, produce two rectangular waveforms each of which is proportional in duration to the selected sweep range.

The positive-going rectangular voltage waveform from the V4002B cathode is applied

to the cathode of sweep generator V4004A. This action cuts off V4004A and a selected capacitor (connected from plate to ground as in a conventional sawtooth generator integrating circuit) charges linearly toward the B supply value. This action develops a positive-going sawtooth voltage at the V4004A plate with a duration equal to that of the blocking pulse at the V4004A cathode. At the trailing edge of the blocking pulse, V4004A again conducts heavily, and the sawtooth voltage drops almost immediately to its zero level. Sawtooth linearity is improved by using only a fraction of the total charging time of the integrating network.

A range select switch (fig. 13-8) selects the width of the range gate pulse and the size of the V4004A plate capacitor. The sweep length control is a potentiometer in the charge path of the V4004A sawtooth charging capacitor. This control is a sawtooth slope adjustment, and is used to align the end of the sweep trace with the last marker etched on the scope screen.

The positive-going sawtooth waveform at the sweep generator plate (fig. 13-9) is coupled to the sweep inverter amplifier which comprises V4003A and V4003B. This circuit is a para-phase amplifier whose outputs are applied in

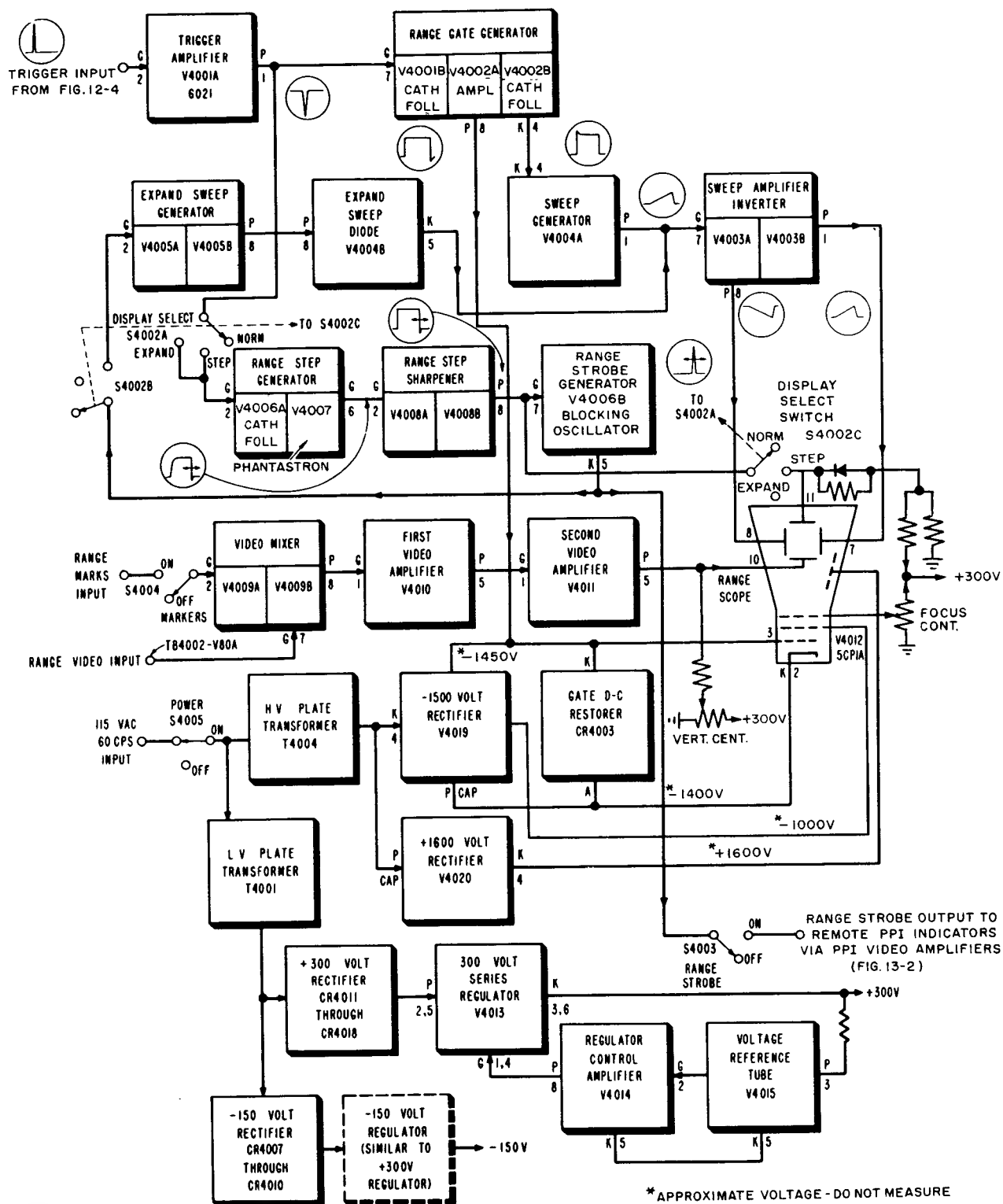


Figure 13-9.—Ranging section block diagram.

032.237

push-pull to the horizontal deflection plates of the cathode-ray tube, V4012. Application of the sweep voltage to both horizontal plates rather than one, as is sometimes the case, provides more linear horizontal control of the electron beam across the entire screen.

Because the stages of the range indicator require an input trigger pulse to produce a sweep trace its action is that of a synchroscope. In the absence of the trigger pulse, the control grid of the cathode-ray tube is made sufficiently negative with respect to the cathode to blank the appearance of the sweep trace. The action is described below.

The arrival of the trigger pulse at V4001A causes the generation of two output pulses from the range gate generator as discussed. The positive-going output at the V4002A plate is applied as an unblanking pulse to the control grid of the cathode-ray tube, V4012. This action permits the CRT to produce a visible sweep trace for the duration of the unblanking (gate) pulse.

Gate d-c restorer CR4003 which is shunted by a large resistance (not shown) time constant charge path during the time the unblanking pulse is applied to the V4012 grid and a short time constant discharge path. The short time

constant removes the charges accumulated during the pulse and ensures that the grid of V4012 will be returned to its original potential before the next unblanking pulse is applied. This action prevents successive traces from becoming brighter as a result of accumulated positive charge at the V4012 grid and tends to maintain uniform brilliance for each sweep trace.

#### Range Step Generator

The range step generator (fig. 13-9) consists of a cathode follower, V4006A and a phantastron, V4007. This circuit generates a rectangular variable-width waveform termed the "range-step."

A display select switch on the front panel of the range indicator (fig. 13-8) permits a normal display on the CRT screen in the NORM position (fig. 13-10A), a normal display with range step pulse added for ease in range determination in the STEP position (fig. 13-10B), and an expanded sweep display for expanding the trace around the target in the EXPAND position (fig. 13-10C).

When the display select switch (fig. 13-9) is in the STEP position, the range step marker output from V4007 is applied through a range

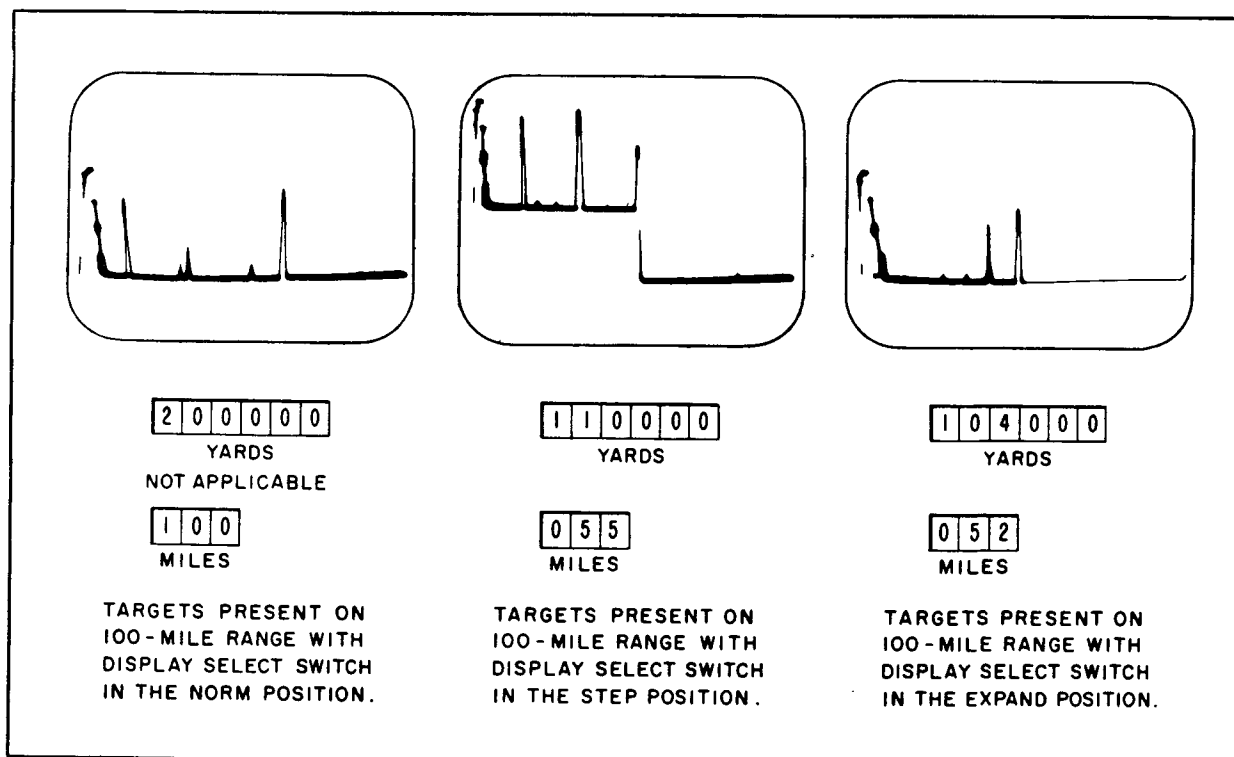


Figure 13-10.—Range indicator presentations.<sup>032.238</sup>

step sharpener, V4008A and B, to one vertical deflection plate of the cathode-ray tube, V4012. The trailing edge of the V4007 (phantastron) output is varied by a range step crank (fig. 13-8). By application of the step voltage to the vertical plate of the CRT a step is produced in the sweep trace, and by adjusting its trailing edge for coincidence with the leading edge of the video (echo) pulse, the target distance can be read out directly in miles and/or yards on range counters. The counters are mechanically ganged to the range step crank.

In the 5- and 25-mile ranges of the range select control, the yards indicator counts in increments of 100 yards from 500 to 50,000 yards and the miles indicator counts in tenths of miles from 0.2 to 25 miles. In the 100- and 250-miles range, the yards indicator counts between 5000 and 500,000 yards in steps of 1000 yards and the miles counter rotates between 2 and 250 miles in 1-mile increments. Range measurements are obtainable within a tolerance of  $\pm 0.75$  percent of the indicated range  $\pm 100$  yards.

When the display select switch S4002A (fig. 13-9) is in either the EXPAND or STEP position, the pulse from V4001A triggers the range step generator at the same time the range gate generator (sweep) circuits are triggered. Thus, the range step pulse begins at the instant the sawtooth sweep begins.

The range step output is always applied to the grid of range strobe generator V4006B. However, the V4006B cathode is completed to ground through S4002B only when this switch is in the EXPAND position. The ground path is completed through the grid-to-ground resistance at the input to expand sweep generator V4005A.

With S4002B in the EXPAND position, a positive-going trigger pulse is applied at the grid of V4005A which corresponds with the trailing edge of the range step. The purpose of this pulse is explained below.

#### Expand Sweep Circuits

The expand sweep circuits consist of V4005A, V4005B, and V4004B (fig. 13-9). Stage V4005 is a one-shot (monostable) multivibrator. The positive-going trigger pulse at the V4005A input, as discussed, triggers multivibrator V4005 into operation. The positive-going square wave output of V4005B is fed through V4004B to the sweep generator plate. This voltage adds to the potential across the sweep generator, V4004A, output integrating network for approximately

30  $\mu$ s when the display select switch is in the EXPAND position. The additional voltage causes the sweep charging capacitors to charge more rapidly, increasing the slope of the sawtooth wave. The increased slope (voltage change with respect to time) for the duration of the 30  $\mu$ sec expand pulse causes an increase in sweep speed during the period of the expansion pulse. Because of this action the information normally presented in a given period is expanded to cover a larger portion of the CRT. This is illustrated in figure 13-11.

After expansion, closely spaced targets such as shaded pulses, 1, 2, and 3, are relocated to position indicated by unshaded pulses 1, 2, and 3. Any target such as 5 which is displayed before the expansion range, is not affected.

#### Range Strobe Circuits

The range strobe generator, V4006B (fig. 13-9), produces a variable-range marker that can be applied to the remote PPI-type repeater. The range strobe circuit is a positive-going voltage spike which appears on the indicator screen as a bright spot coincident with the variable trailing edge of the range step. The position of the range strobe corresponds to the distance indicated on the range counters. Thus, the strobe is helpful in accurately determining target range.

When the range strobe switch, S4003, is in the ON position, the range strobe output may be fed to the remote PPI-type indicators via the PPI video mixer, V1704 (fig. 13-2). The strobe mixes with the video signal before it is applied to the indicator. The range strobe may also be coupled to any other auxiliary equipment through a 75-ohm coaxial line.

#### Video Circuits

The video stages (fig. 13-9) consists of a video mixer, V4009A and B, and two video amplifiers, V4010 and V4011, respectively. The video signal is applied to V4009B from the radar receiver via range video output stage V1706 (fig. 13-2). Range mark signals (if used) are applied to V4009A. The two input signals are mixed in V4009B.

Stages V4010 and 4011 amplify the radar video signals which are developed in the receiving section as discussed. The signals are then applied to one of the range indicator vertical deflection plates in a manner that causes them to appear as vertical pulses above the sweep base line. When range mark signals are

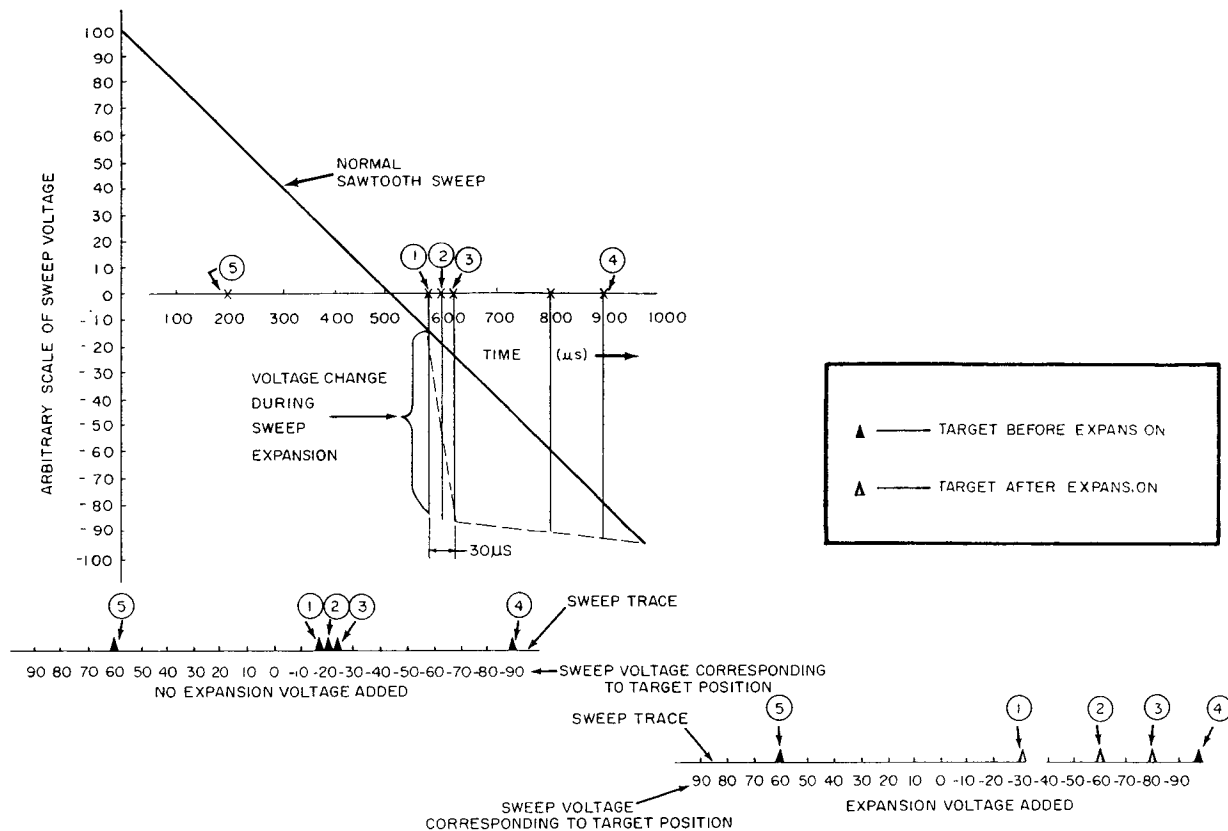


Figure 13-11.—Expanded sweep waveshapes. 032.239

used they appear as vertical spikes below the radar sweep line and are used to estimate target range.

#### POWER SUPPLIES

The high potentials required by the range indicator cathode-ray tube are produced in two half-wave rectifiers, V4019 and V4020 (fig. 13-9). High voltage transformer T4004 steps up the input 115Vac line voltage to supply both rectifier tubes.

The d-c potentials on the various electrodes of the CRT are approximate and are used to illustrate the overall influence of the electrodes on the electron beam from cathode to screen. These potentials are dangerous to life and should not be measured from the V4012 tube socket with external test equipment.

Regulated d-c potentials of +300 and -150 volts are produced in the range indicator chassis for all of the range indicator stages. Both the +300 and -150 volt regulated supplies (schematic not shown) are composed of full-wave bridge-type rectifiers, choke input filters,

and standard series electronic voltage regulator circuits.

#### MONITORING SECTION

The monitoring section (fig. 13-12) contains video input circuits, an oscilloscope, and self-contained power supplies. An input selector makes it possible to check the trigger generating, modulating, transmitting, receiving, and ranging sections.

The oscilloscope (fig. 13-13) is located in, and is a part of, the control-monitor group. It provides rapid localization of a fault in the other sections of Radar Set AN/SPS-29.

After the fault has been isolated to a certain section, the oscilloscope can be removed from the control-monitor group and used to isolate the trouble within the faulty section.

The oscilloscope is of the synchroscope type and receives its synchronizing trigger pulse from the trigger generating section (fig. 12-4). The video inputs to the synchroscope are selected from the control panel of the control-monitor group (fig. 12-1C).

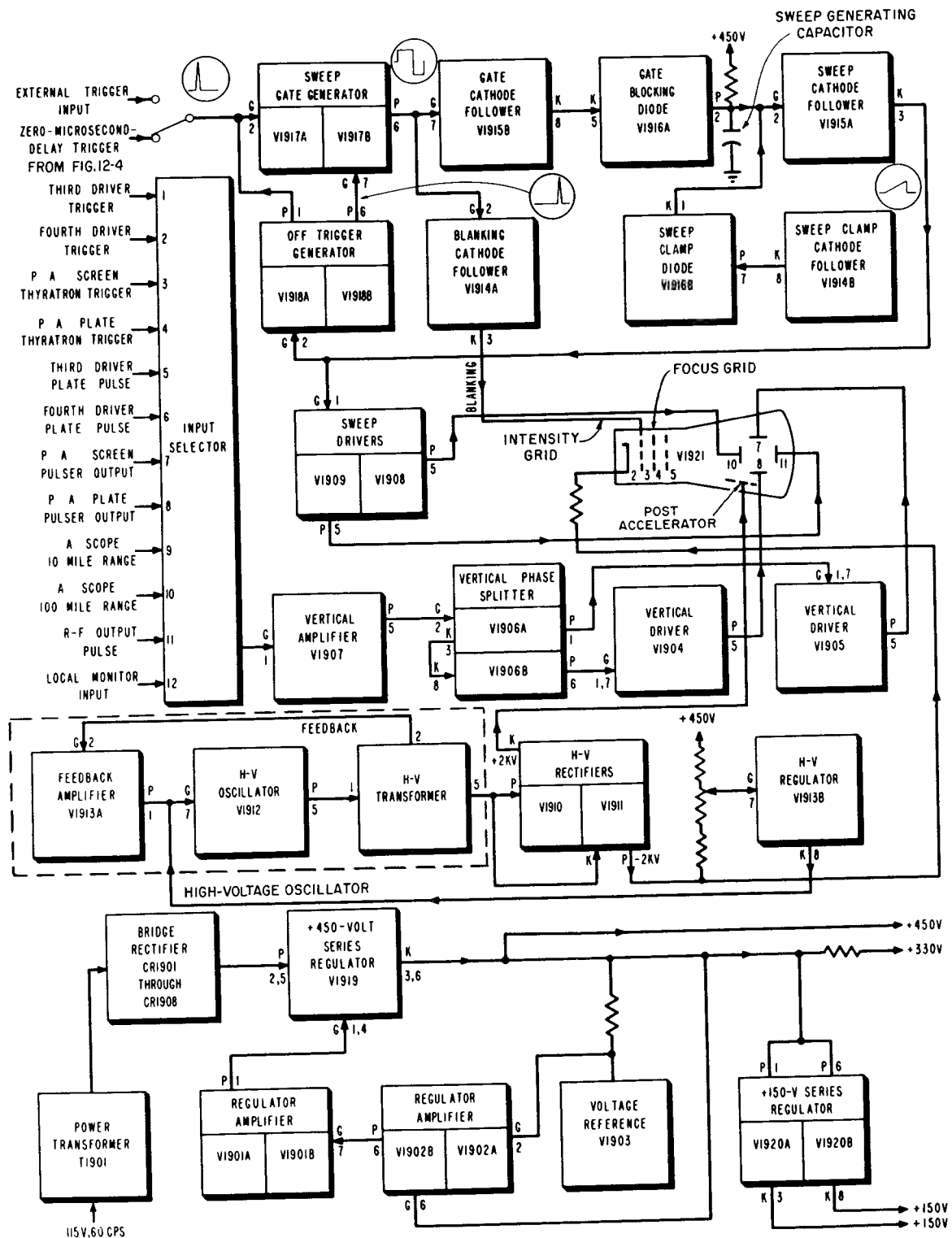


Figure 13-12.—Monitoring section, block diagram.

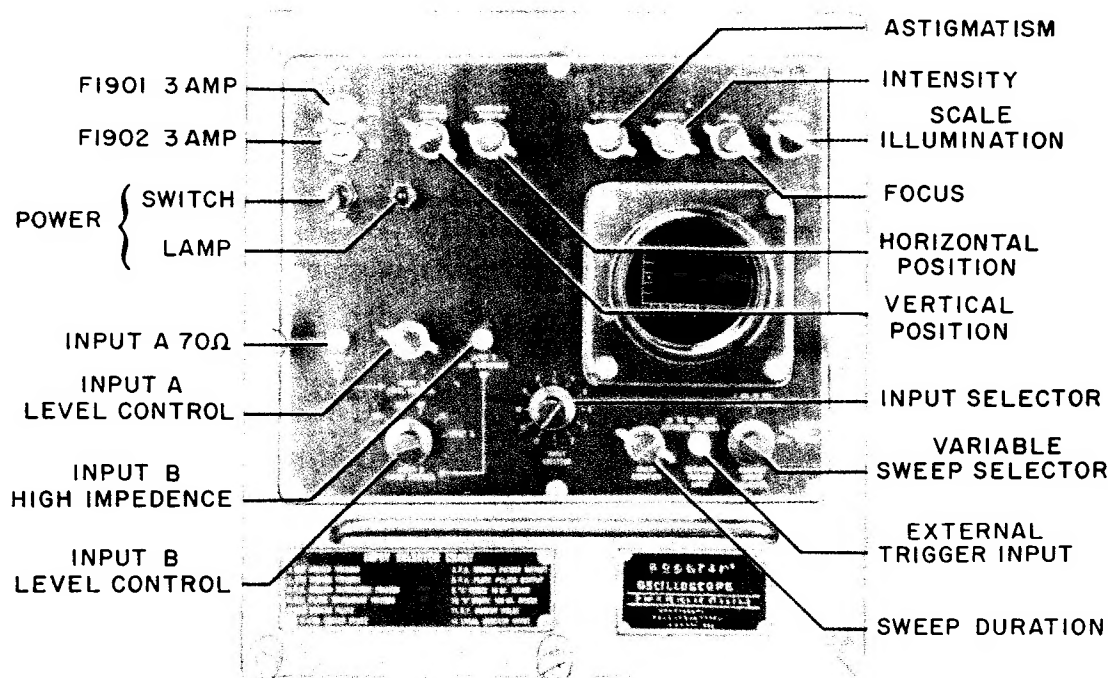


Figure 13-13.—Control monitor group oscilloscope. 032.241

## VERTICAL SECTION

The input selector feeds the signal or waveform to be observed from the various sections of the radar system to vertical amplifier, V1907 (fig. 13-12). The amplified signal from V1907 is applied to the grid of vertical phase splitter, V1906A. Tube V1906 is a duo-triode with the inverted output from its A section coupled simultaneously to the B section of the tube and to vertical driver V1905. The V1906 plates produce output of equal amplitude but opposite phase. The positive-going video signal at the plate of V1906A is applied to the grid of V1905 as discussed, while the negative-going signal at the plate of V1906B is applied to the grid of vertical driver V1904. The resulting negative-going signal at the V1905 plate and positive-going signal at the V1904 plate drive the vertical deflection plates of the cathode-ray tube, V1921, in a push-pull manner.

## HORIZONTAL SECTION

The 0  $\mu$ Sec delay sweep trigger from the pulse generator (fig. 12-4) is applied to the A section grid of sweep gate generator V1917. This stage is connected as an Eccles-Jordan (bi-stable) multivibrator. With the occurrence

of the trigger at the grid of V1917A, the A section conducts heavily and V1917B is driven into cutoff. The resulting positive-going square waveform (sweep gate) developed at the plate of V1917B is coupled to the grids of gate cathode follower, V1915B and V1914A. The positive-going waveform at the V1914A cathode intensifies the electron beams of the cathode-ray tube, V1921, and thereby unblanks V1921 during the occurrence of the sweep.

As foretasted, the positive-going sweep gate waveform from V1917B is applied to the V1915B grid. This waveform is reproduced, without polarity change, at the V1915B cathode and applied to the cathode of V1916A. In the absence of the input pulse, V1916A conducts heavily. When the pulse is applied, V1916A cuts off, and the sweep generating capacitor connected from the V1916A plate to ground starts to charge through a large resistance (long time constant) path toward the B supply value. A positive-going linear sawtooth waveform is thus applied to the sweep cathode follower, V1915A grid, and coupled simultaneously from the V1915A cathode to sweep driver, V1909, and to the A section of off-trigger generator V1918.

The off-trigger generator is connected as a one-shot multivibrator. When the amplitude of the sawtooth waveform developed across the



sweep generating capacitor reaches a predetermined value, the off-trigger generator (section V1918A) is driven into conduction while section V1918B is driven into cutoff. A positive-going waveform is developed at the plate of V1918B, which is applied to the grid of sweep gate generator, V1917B. Stage V1917B, which has remained in the conducting condition since the time of the sweep input trigger at V1917A, is now driven back into conduction and its plate potential is suddenly decreased.

Because of the negative-going swing in the V1917B plate voltage, the grid of the blanking cathode follower and the grid of the gate cathode follower are both driven negative. The negative-going output of V1914A drives the grid of the cathode-ray tube (V1921) more negative and the tube is blanked. The negative-going decrease at the V1915B cathode decreases the blocking bias on V1916A allowing this tube to again conduct and provide a low resistance (short-time constant) discharge path for the sweep generating capacitor. This action completes the sweep cycle which is not repeated until another sweep trigger pulse is received from the pulse generator as discussed.

Sweep clamp diode V1916B and sweep clamp cathode follower V1914B comprise a sweep clamping circuit which holds the sweep voltage at a constant d-c reference level during the blanking time to ensure that the sweep trace begins at the same position on the V1921 screen for each subsequent trace.

The positive-going sawtooth sweep waveform developed at the plate of sweep driver V1908 and the negative-going sawtooth sweep waveform developed at the plate of sweep driver V1909 are applied to respective horizontal deflection plates of the cathode-ray tube and causes the electron beam to produce a trace across the face of the tube. The plate potential of V1908 is held at a quiescent level determined by the setting of a horizontal centering control (not shown). The setting of the centering control changes the d-c potential between the two horizontal deflection plates and determines the horizontal position of the sweep trace.

#### POWER SUPPLIES

The oscilloscope chassis contains a low voltage and high voltage power supply. The low voltage supply provides operating potential of +450 v, +330 v, and +150 v for the receiving type tubes contained in the oscilloscope, and is conventional in design. The high voltage supply provides d-c operating potential for the cathode and accelerating anode of the cathode-ray tube.

The high voltage power supply comprises a high voltage oscillator, a high voltage rectifier circuit, and a high voltage regulator circuit. A schematic diagram of the high voltage power supply is shown in figure 13-14.

The high voltage oscillator, V1912, is similar to a Hartley oscillator since the feedback from plate to grid is obtained via a tap (terminal 2) on T1903. The tuned circuit for the oscillator comprises the T1903 primary and its distributed capacitance.

The feedback voltage at terminal 2 of T1903 is coupled through C1916 to the control grid of feedback amplifier V1913A. The amplification of the feedback signal provides more positive control of the oscillator and increases the magnitude of the oscillator output. An increase in the V1912 plate current causes a negative-going potential at terminal 2 of T1903. This negative-going input at the V1913A grid causes an increase in the V1913A plate potential and a corresponding increase in the V1912 grid potential. The action causes the V1912 plate current to increase further. Thus, the feedback signal is regenerative, and oscillations in V1912 are sustained.

The oscillator output is stepped-up in the secondary (5-4) winding of T1903 and rectified by V1910 and V1911. The rectifier tubes conduct on alternate half-cycles so that the V1910 output to filter C1908 is a positive d-c series of pulses whose ripple frequency is the same as the oscillator frequency. The V1911 output, filtered by C1918, is a negative d-c series of pulses at the same ripple frequency. The peak amplitude of the positive or negative output is slightly higher than 2 kilovolts.

The rectifier circuits contain separate bleeder networks for discharging its associated filter capacitor. The bleeder network of the negative rectifier circuit is also used as a voltage divider, and provides intensity, focus, and H-V adjust controls.

The high voltage output is regulated within limits by high voltage regulator V1913B. The cathode resistor, R1937, of V1913B is connected to ground and the plate is connected to +450 volts. Thus, the cathode voltage may vary between ground and some positive value, depending upon the control grid voltage of V1913B.

The V1913B grid is connected to the arm of H-V adjust potentiometer R1934, which forms a portion of the negative rectifier bleeder network which is connected between the -2 kv and +450 v supplies. Normally, the V1913B cathode is about 70 volts to ground while the grid is about 60 volts to ground. If the position of the R1934

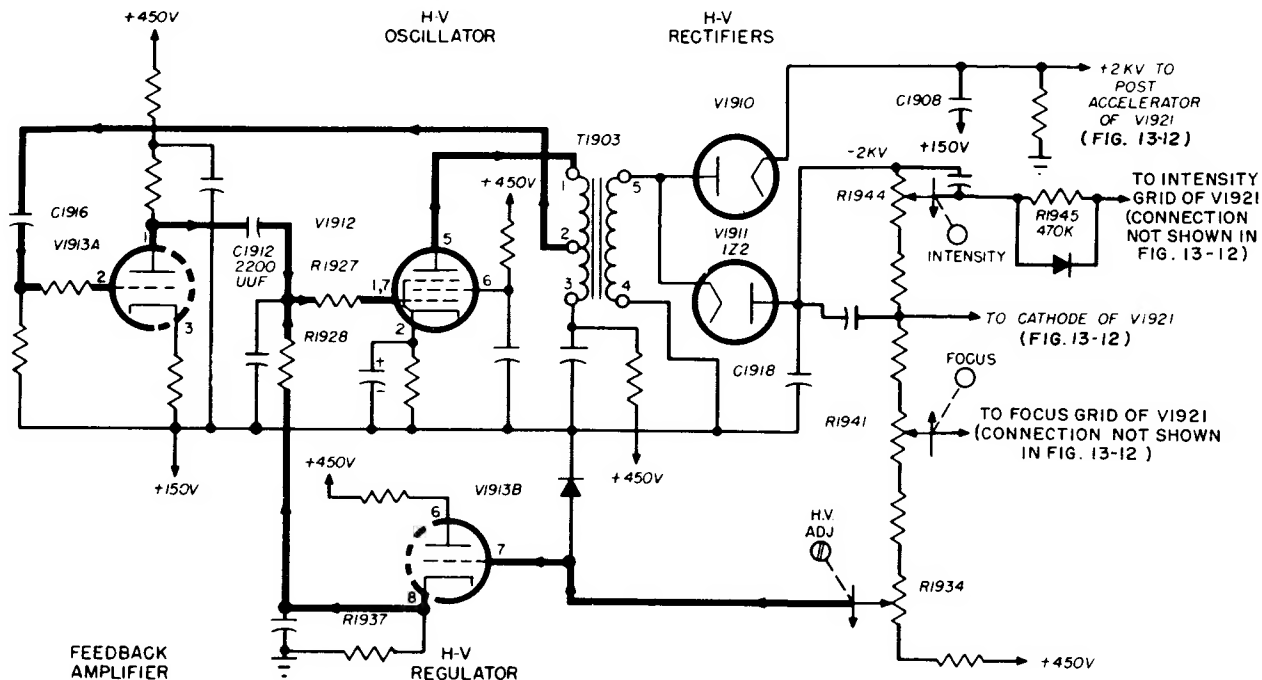


Figure 13-14.—High voltage power supply. 032.242

arm is changed, the cathode voltage changes accordingly. The change in the V1913B cathode potential is applied through R1928 and R1927 to the oscillator (V1912) grid as a corrective voltage. Stage V1913B is a high mu triode, so that small changes at the R1934 will produce a large correcting affect at the V1912 grid. If the V1912 grid is driven in the less negative direction, the amplitude of the oscillations increases to produce a corresponding increase in the rectified output from V1910 and V1911. A more negative grid would produce the opposite effect at the output of the H-V rectifiers.

Regulation is provided automatically if the oscillator output amplitude tries to change as a result of minor changes in circuit constants in the oscillator or if the load on the H-V rectifiers changes. The H-V rectifier load, which consist of the CRT cathode (on the H-V supply) and accelerating anode (on the +H-V supply) is relatively constant and should not vary sufficiently to effect a change in the high voltage output. Voltage changes may, however, be introduced in the output by a defective or aging oscillator tube. This will be the most probable cause for a change in the high voltage output.

Whatever the cause of high voltage change, the response at the R1934 arm will initiate the action to counteract the change as described

above. The amount of correction is dependent upon the mu of V1913B and the setting of the R1934 arm.

The intensity (brightness of the beam) on the cathode-ray tube is controlled by R1944 which varies the negative potential to the intensity grid (pin 3) of V1921 (fig. 13-12). Focusing is accomplished in a similar manner at grid 4 by R1941 (fig. 13-14).

#### LOW VOLTAGE SECTION

The low voltage section (fig. 13-15) includes power supply assembly PP-2033/SPS-29, voltage regulator CN-493/U, and the +150 volt regulator chassis which is a part of the detector-voltage regulator situated in the control monitor.

Power supply assembly PP-2033/SPS-29 consists of the receiver power supply which supplies +230 and +300 volts respectively, the relay power supply with an output of -28 volts, and the -150/+300/+700 volt power supply which is monitored by M2202. The power supply assembly supplies unregulated d-c potentials for stages in the modulating, transmitting, and receiving functional sections.

Voltage regulator CN-493/U maintains one of the 115-volt single-phase line inputs within

one percent of rated voltage. The regulated 115-volt a-c output is applied to the circuits of the

receiver power supply, and to the transmitter control circuits that require regulated power.

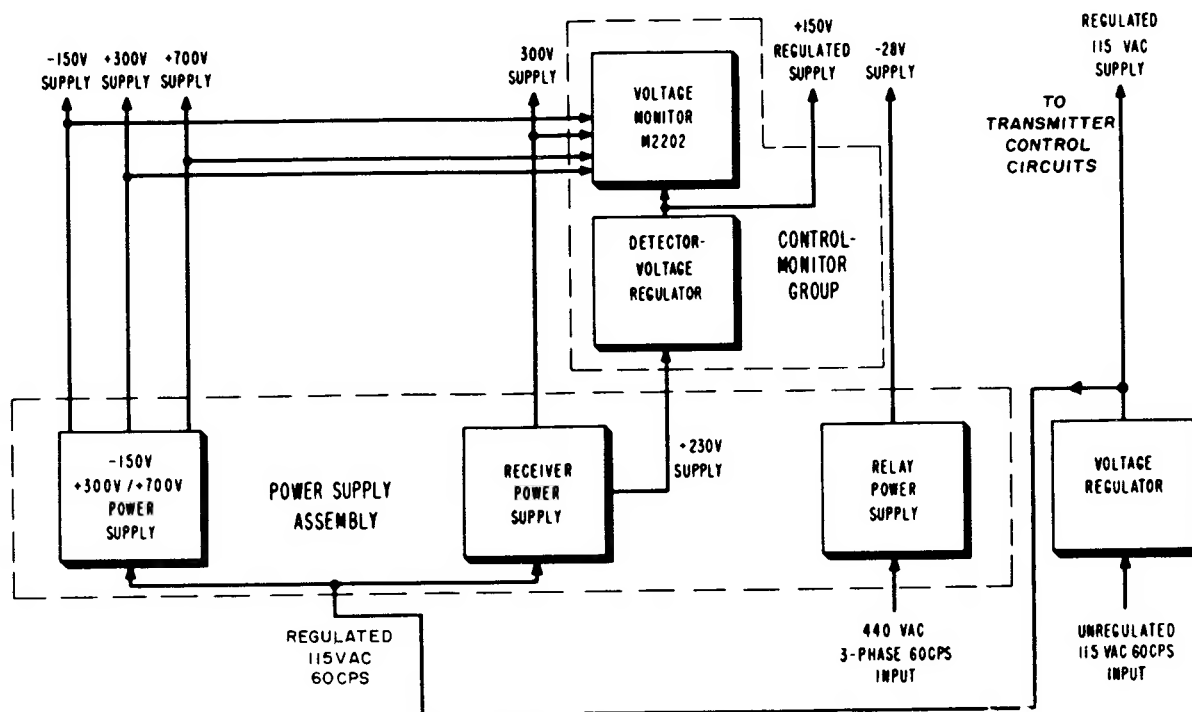


Figure 13-15—Low voltage section. 032.243